

# Reduce Fuel Costs - Use the Proper Air-to-Fuel Ratio in Boiler Combustion

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Do you know what the most common energy and cost saving opportunity in a steam system is? According to the results of 41 steam plant audits performed by Enbridge Consumers Gas of Toronto, Canada, the answer is combustion improvement. The 41 audits, which frequently involved multiple boilers in one plant, revealed a total of 45 opportunities for combustion improvement projects involving any or all of the following: boiler tune-ups, combustion control repair, burner repair, and repairs to existing oxygen trim systems. With an average payback period of less than half a year, optimizing steam system combustion is a proven and effective way to reduce operating costs. Combustion efficiency is also a subject addressed by one of a series of BestPractices Steam Tip Sheets produced by the U.S. Department of Energy (DOE) (see sidebar).

A simple, low-cost way of optimizing combustion is to maintain the proper air-to-fuel ratio in your boiler operations. To completely combust the fuel, there needs to be a slight excess of oxygen, since real-life combustion conditions are never capable of achieving the perfect stoichiometric air-to-fuel ratio. Too little air causes incomplete combustion of fuel resulting in excessive soot and fireside fouling, as well as an explosion hazard. Excess air creates fireside fouling and sends thermal resources up the stack. Extremes in either direction create air pollution and costly inefficiency by wasting fuel.

Combustion improvements "are almost universally required," according to Bob Griffin, who leads the Enbridge Consumers auditing effort. A general rule of thumb is that boiler efficiency can be increased by one percent for each 15 percent reduction in excess air or 40°F reduction in stack gas temperature. The appropriate amount of excess air for optimal combustion varies with the type of fuel and burner in a system. The U.S. DOE's BestPractices Steam program asserts that for well-designed natural gas fired systems, an excess air level of 10 percent is attainable.

BestPractices Steam, a U.S. DOE initiative, generates references, diagnostic software, case studies, and industry outreach events for the benefit of the industrial steam community. A series of 19 steam tip sheets is available. Each is one page, providing an overview and an example for calculating its economic impact.

The tip sheet entitled *Improve Your Boiler's Combustion Efficiency* provides further details and an example of the savings realized by optimizing a boiler's air-to-fuel ratio.

An article that details the Enbridge Consumers steam audit findings is included in *Steam Digest 2001*, available for free by calling the BestPractices Clearinghouse (contact info below). Alternatively, the article may be downloaded from <http://www.oit.doe.gov/bestpractices/steam/pdfs/ecreport.pdf>.

Readers are encouraged to download Steam Tip Sheets and other resources, free of charge, from [www.oit.doe.gov/bestpractices](http://www.oit.doe.gov/bestpractices) and from [www.steamingahead.org/resources.htm](http://www.steamingahead.org/resources.htm). Printed copies may also be requested from the BestPractices Clearinghouse: (800) 862-2086 or [clearinghouse@ee.doe.gov](mailto:clearinghouse@ee.doe.gov).

The first step in determining the proper amount of excess air is to measure the current amount of oxygen in the flue gas. This can be done with a gas absorbing test kit or an electronic flue gas analyzer. Two additional measurements required are the temperature of the flue gas and the temperature of the air going into the boiler. Unless you have an electronic tester that calculates the combustion efficiency based on these measurements, you will need to reference an efficiency table or graph for the specific fuel being combusted. Combustion efficiency tables or graphs come with test equipment, are available in reference books, and are included in the BestPractices' *Steam System Survey Guide*, found online at: [http://www.oit.doe.gov/bestpractices/steam/pdfs/steam\\_survey\\_guide.pdf](http://www.oit.doe.gov/bestpractices/steam/pdfs/steam_survey_guide.pdf).

## CALCULATING THE OPERATING COST SAVINGS

You can demonstrate the amount of money your facility will save by instituting a regular air-to-fuel ratio measurement and adjustment practice for your boiler(s). The general formula for showing the savings associated with optimized boiler combustion efficiency is as follows:

$$\text{Cost Savings} = \text{Fuel Consumption} \times (1 - E1/E2) \times \text{Steam Cost}$$

...where E1 is the existing combustion efficiency percentage and E2 is the optimized combustion efficiency percentage. A sample calculation can be found on the BestPractices steam tip sheet entitled *Improve Your Boiler's Combustion Efficiency* (see sidebar for website and contact information).